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EFFICACY OF PLANTING METHODS AND MULCHING UNDER DRIP IRRIGATION ONYIELD, WATER USE EFFICIENCY, WATER PRODUCTIVITY AND ECONOMICS OF CAULIFLOWER (BRASSICA OLERACEA VAR. BOTRYTIS)

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ABSTRACT

The field experiment was undertaken to study the efficacy of planting methods and mulching under drip irrigation on yield, water use efficiency, water productivity and economic return of cauliflower in acidic soil of Eastern Plateau Hill Region of India. The treatments of the study comprised different combinations of three planting methods viz., flat bed, broad bed and ridge & furrow under drip irrigation in conjunction with or without LLDPE mulch of bi colour silver black 25 micron thickness. The mulched treatments irrespective of methods of planting revealed significantly higher yield, water use efficiency, water productivity and economic returns as compared to the without mulched. The ridge and furrow either alone or in conjunction with mulch gave significantly highest yield. The ridge and furrow with mulch gave highest cauliflower average curd yield 1.05 kg plant^{-1}, curd yield 40.42 t ha^{-1}, irrigation water use efficiency 11.88 kg m^{-3}, gross economic water productivity 118.78 Rs m^{-3} and benefit cost ratio was also found highest (1.63) with net return of Rs 1, 55,672 ha^{-1}. The mulched planting system recorded significantly high moisture content over non mulched treatment. The mulch alone increases the yield by 29.5 %, 28.07 % and 29.8 % in flat bed, broad bed and ridge and furrow method of planting over without mulched. The highest moisture content was 14.5 and 13.9 % during crop growth period under mulched ridge and furrow system. The method of planting showed enhancement of yield up to an extent of 8.18 % (flat bed vs. broad bed), 15.72 % (flat bed vs. ridge and furrow) and 6.97 % (broad bed vs. ridge and furrow). The polythene mulched treatment also showed significant gain in N, P and K balance with simultaneous increase in crop nutrient uptake and soil available nutrient. The highest actual gain of N and K was 22 kg ha^{-1}. The ridge and furrow with mulch compared to flat bed without mulch gave 50.2 % higher yield. The maximum net return of 185.12 % was recorded in flat bed with mulch in compared to without mulch followed by broad bed with mulch and without mulch (140.19%) and least in ridge and furrow with and without mulch (113.62 %) respectively. The study reveals method of planting under drip irrigation in conjunction with mulch has an explicit role in increasing the land and water productivity of cauliflower.

KEYWORDS: Planting Methods, LLDPE Mulch, Water Use Efficiency, Gross Economic Water Productivity, Cauliflower & B: C Ratio

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Original Article

INTRODUCTION

Cauliflower (*Brassica oleracea var. botrytis*) is a cool season, frost tolerant herbaceous dicot widely adopted and grown as an annual crop throughout temperate and subtropical reasons of southern and northern hemisphere. China and India are the largest producers of cauliflower and about 70% of the world cauliflower production occurs in Asia (FAO Stat, 2012). Europe produces approximately 20 % of the world's cauliflower. Italy and UK are the leading European

producers. Significant cauliflower production also occurs in North America, where the USA is the leading producers (FAO Stat, 2012). Jharkhand is the sixth major cauliflower producing state in the country. It produces about 0.36 MT *i.e.,* 6 % of total production of cauliflower in the country with national production of 4.694 m MT per year. The area coverage under cauliflower in Jharkhand is 0.02 m ha against coverage of 0.256 m ha in the country. The average productivity of cauliflower in the county is 18.3 m t ha^{-1} and in Jharkhand state is 16 t ha^{-1} in the year 2012 (NHM Report, 2012). However there is possibility of increasing the production in country and Jharkhand in particular of proper soil and water conservation measures are taken up. Cauliflower is relatively easy to transplant because plants root easily and little root mass is required for successful establishment. However, excessive stress during transplanting and establishment can result in pre mature heading. In situ water conservation in the soil profile is the most economic and practical means of ensuring sustainable availability of water to the plants during flowering and curd development. Though cauliflower is frost tolerant and cool season crop, it responds well to irrigation and moisture conservation treatments. Mulching with plastic is a method by which soil moisture can be conserved. Among the water management practices for increasing water use efficiency, there are several practices, one of them being mulching. Mulching also contributed to the crop production by influencing soil productivity, weed control, etc. depending upon the mulches (Asiegbu, 1991).

In Jharkhand, the average annual rain fall is 1400 mm out of which 90 % of the contribution is during monsoon period of June-September. The drip irrigation has proved to be a success in terms of water saving and increased yield in a wide range of horticultural crops. Use of soil cover and mulching is also known to be beneficial through their influence on soil moisture conservation, solarization and control of weeds. Drip irrigation with polythene mulching conserve water and nutrient, which is vital natural resource for enhancing the crop production and productivity. The benefits associated with the use of polythene mulches for vegetable production include higher yields, earlier harvests, improved weed control, cleaner fruit and increased efficiency in the use of water and fertilizer (Pattanaik *et al.,* 2003). It has created interest among the farmers of eastern plateau and hill region of India because of decreased water requirement and possible increase in production. Linear Low Density Poly Ethylene (LLDPE) films have been proved as better mulch because of their puncture resistance, quality, thinness and lower cost. The use of polyethylene mulch in vegetable production was reported to control weed incidence, reduce nutrient loss and improve hydrothermal regimes of soils (Asworth and Hurrison, 1983). Mulching stimulates the microbial activity in soil through improvement of soil agro-physical properties (Strizaker *et al.,* 1989). Mulching also warms the soil and improves the soil physical condition and suppresses weed growth (Mohler and Calloway, 1992). It is therefore imperative to test the performance of drip irrigation in conjunction with mulch and without mulch in Jharkhand condition that is characterized by different soil and climate. Hence with this in background present study was undertaken to investigate the efficacy of methods of planting on different types of beds and mulching on cauliflower under drip irrigation in terms of yield, water use efficiency, gross economic water productivity and economics in acidic soil of Eastern Hill Plateau Hill Region of India.

MATERIALS AND METHODS

The present study was conducted for consecutive four years 2012 to 2015 during the winter season (November-March) at research farm of ICAR-Research Complex for Eastern Region, Research Centre, Ranchi located at $23^{0}16'$ N latitude and 50^{0} 85' E longitude and 629 m AMSL altitude. The soil was sandy clay loam in texture, with pH 5.2, low in available N (250.5 kg ha^{-1}), medium in available P (55.5 kg ha^{-1}) and K (280 kg ha^{-1}). Climate of Ranchi is sub tropical with hot and dry summers and cool winters. The drip system was already installed in the field at the lateral distance of 1m

and all the laterals were placed above the different soil beds. The drippers in each lateral were spaced at 40 cm apart. The experiment was laid out in the randomized complete block design (RCBD) having six treatments replicated four times under each treatment. The treatment comprised as T_{1-} Flat bed (FB); T_{2-} Flat bed with mulch (FB+M); T_{3-} Broad bed (BB); T_{4-} Broad bed with mulch (BB+M); T_{5-} Ridge and furrow (R&F) & T_{6-} Ridge and furrow with mulch (R&F+M). The silver black bi colour Linear Low Density Poly Ethylene (LLDPE) film of 25 micron thickness was used for mulching on prepared bed as per the treatment and carefully holes were punctured where seedlings were to be established. The 30 days old F_1 hybrid of cauliflower Girija seedlings were transplanted on 15th November of each year 2012 to 2015 at 60 cm x 45 cm spacing of row to row and plant to plant. Well decomposed cow dung applied (5 t ha^{-1}) prior to final tilling. The fertilizer was applied as 120:45:45 kg NPK ha^{-1}. The uniform cultural practices were followed as per the standard recommended practices to all treatments. The uniform water was applied to cauliflower through drip irrigation. At 40 days after transplanting, weeds were collected from the plots and their fresh weights were recorded. After the harvest of crop, soil samples were collected at a depth of 0-15 cm. Composite soil samples are then made for each plot. These were then dried in shade on ground and passed through 2.0 mm sieve. The available N content in soil was determined by the method described by Subbiah and Asija (1956), available P by Bray and Curtz (1945) and exchangeable K by flame photometer (Jackson, 1973).

The cauliflower crop evapo transpiration was calculated using pan evaporation method (Doorenbos and Pruitt, 1977). The crop co-efficient was also determined as suggested by Doorenbos and Pruitt (1977). The actual crop water requirement was estimated by multiplying reference crop evapo transpiration, crop coefficient, area under each plant and wetting fraction. The water requirement of crop was computed on daily basis by using the following equation as suggested by Shukla *et al.,* 2001 as $V = E_pK_pK_cS_pS_rW_p$, where V = Volume of water required (litre/day/plant), E_p = Pan evaporation as measured by Class-A pan evaporimeter (mm/day), K_c = Crop co-efficient, K_p = Pan co-efficient, S_p = Plant to plant spacing (m), S_r = Row to row spacing (m), W_p = Wetted area, The water requirement of cauliflower crop was estimated on daily basis for cropping season of consecutive years. Daily time to operate the drip irrigation system was worked out taking the application rate per plot. Drip irrigation was scheduled daily, hence total quantity of water delivered was cumulative water requirement of each day minus effective rainfall. The lateral lines of 12 mm diameter LLDPE pipes were laid out along the crop rows and each lateral served each row of crop. The laterals were provided with on line turbo key dripper of 2.4 lph discharge capacity.

Benefit cost analysis was also carried out to determine the economic feasibility of the crop using drip irrigation as per Tiwari *et al.,* 1998. The seasonal system cost of drip irrigation system includes depreciation, prevailing bank interest rate, repair and maintenance cost of the system. The interest was taken 12% and repair and maintenance cost of the system was taken 2% per annum of the fixed cost. The useful life of drip irrigation system was considered to be 10 years. The cost of cultivation includes the expenses incurred in inter culture operation, fertilizer, crop protection measures, irrigation water and harvesting with labour charges. The income from produce was estimated using prevailing average market price of Rs.10, 000 ton^{-1} and accordingly the benefit cost ratio and net profit was calculated.

RESULTS AND DISCUSSIONS

The soil moisture content during the crop growth period of cauliflower under different systems of planting with and without polythene mulch is shown in Fig. 1. The mulched planting system (T_2, T_4 and T_6) recorded significantly ($P \leq 0.05$) high moisture content over without mulched (T_1, T_3 and T_5) treatment. However, there is no significant ($P > 0.05$)

difference among the mulched planting system. The highest moisture content was 14.5 and 13.9 % during crop growth period of cauliflower under mulched ridge and furrow system (T_6). The moisture content during crop growth period of cauliflower in polythene mulched planting system registered 25.2 % increase over without mulched system. The polythene mulched flat bed, broad bed and ridge and furrow planting resulted in 30.0, 31.2 and 28.2 % increase in soil moisture content over without mulched system. LDPE mulch with different methods of planting (T_2, T_4, T_6) percentage increase in yield were recorded to be 29.5 %, 28.07 %, & 29.8 % respectively as compared to the without mulch (T_1, T_3, T_5). Increased moisture retention capacity due to mulching with polythene could be attributed to less evaporation from the soil. Because of vapors, the water was further trapped within the mulches, resulting in fog which again dropped into the upper soil layer. Wang *et al*., (1998) reported that all type of polythene mulch increased the soil moisture content in chilli field compared to control.

The four years pooled data of biometric parameters like plant height, number of leaves per plant, weed biomass occurrence and average yield attributing characters such as number of curd initiation, average curd yield per plant and yield of cauliflower curd as influenced by planting methods in conjunction with or without LLDPE mulch in cauliflower are depicted in Table 1, 2 & 3. The results revealed that, these characters and yield are significantly superior in the treatment T6 (R&F+M) as compared to the rest of the treatments. The average height at initial stage up to 30 days after transplanting showed significant difference among different mulched and without mulched treatments. The mulched treatment irrespective of methods of planting recorded significantly higher plant height for consecutive four years. The treatment ridge & furrow with LLDPE mulch recorded maximum average plant height of 31.88 cm than the average minimum of 22.47 cm under flat bed without mulch. The similar results was obtained by Ashrafuzzaman *et al.,* 2011 that increase in plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. However, afterwards the plant height has no significant affect irrespective of mulch or without mulched treatments consecutive of four years. As regards to number of leaves, average maximum value was recorded in ridge and furrow with mulch T6 (19.27) followed by ridge and furrow without mulch T5 (18.94) and lowest value in flat bed without mulch T1 (17.38). The highest initiations of curd were recorded in treatment with mulched one. The curd initiation in cauliflower among all the treatments was counted at 70 days after transplanting. The ridge and furrow with mulch in consecutive four years recorded maximum average number of curd initiation of 33.0 which was 125.56 % higher than ridge and furrow without mulch. In different methods of planting the mulched treatment flat bed recorded highest percentage increase of 328.27 % followed by broad bed 314.67 % and least in ridge and furrow of 125.56%. This reveals that the ridge and furrow is the best method of planting in cauliflower. The highest increase in vegetable growth in mulched treatment irrespective of methods of planting might be due to maintain of soil moisture as well as temperature at optimum level as compared to the lowest value in without mulch. This may be because of moisture stress in the soil and competition of nutrients with weeds. The method of planting of different beds as flat bed, broad bed and ridge and furrow, mulches increased the soil moisture content considerably. The yield attributes as influenced by planting methods in conjunction with or without mulch in cauliflower are presented in Table 3. The methods of planting in combination with mulch significantly increased the yield of cauliflower as compared to without mulch. The mulched treatments irrespective of methods of planting recorded higher curd yield plant^{-1} in cauliflower. The highest average weight of curd plant^{-1} for consecutive four years were recorded in mulched treatments (T_2, T_3 and T_6) in comparison to without mulched treatments (T_1, T_3 and T_5). Plants in mulching treatments entered the maturation phase sooner and their maturation period was longer. The longer maturation period was favorable to partition assimilate, stored in vegetative organs, thus facilitated

development of the reproductive organs and increased the duration of reproductive period resulted in enhanced yield (Li *et al*., 2001). However, there is no significant ($P > 0.05$) difference in curd yield between polythene mulched broad bed (T_4) and ridge and furrow system (T_6). Among various treatments highest curd yield per plant was recorded in ridge and furrow with mulch of 1.05 Kg followed by flat bed with mulch (1.02 kg) and broad bed with mulch (1.0 kg). The methods of planting with mulch significantly increased the yield of cauliflower curd as compared to the un mulch. This result was found in conformity with Ashrafuzzaman *et al.*, 2011 that the mulch had positive effect and produced the highest fruit weight per plant and per ha in chili. The mulched treatment in general showed higher yield in comparison to un mulched. The ridge and furrow with mulch recorded highest average cauliflower curd yield of 40.42 t ha^{-1} followed by broad bed with mulch (37.28 t ha^{-1}) and flat bed with mulch (34.85 t ha^{-1}) whereas in without mulch treatment also highest curd yield of 31.14 t ha^{-1} recorded in ridge and furrow followed by broad bed (29.11 t ha^{-1}) and flat bed (29.38 t ha^{-1}). The higher yield observed in mulched treatment might be due to the availability of soil moisture as well as temperature at optimum level (Pattanaik *et al*., 2003). The lowest yield in un mulched treatments might be because of unfavourable moisture regime (moisture stress) in the soil and competition of weeds for nutrients (Pattanaik *et al*., 2003). The higher yield in mulched treatment was attributed to the maximum number of leaves of plants grown on broad beds and ridge and furrow, which might have increased photosynthesis and availability of carbohydrates for cauliflower growth and curd development. Andino and Motsenbocker, 2004 also reported the similar findings as use of polythene mulch promotes changes in the microclimate of the plant, favoring growth and vigor, production and yield of crops. Similar reports has been reported by Kumari (2012) that black polythene mulch plus drip irrigation conserved soil moisture, stimulated shoot growth, and produced higher leaf area and yield in potato.

Among the method of planting ridge and furrow was the best for cauliflower curd yield followed by broad bed and flat bed. The reason of low yield in flat bed without mulch crops may be due to the crop has to undergo water stress during curd initiation and development or throughout the cropping season. Again the reason may be attributed to high weed infestation between the crops. This result corroborated with the findings of Mishra *et al.,* 2008 that mulch with drip irrigation in cashew yielded 109 % higher than basin irrigation. Based on the average yield of four years, all the mulched LLDPE treatment with drip irrigation of methods of planting i.e., $T_{2,}$ T_4, and T_6 resulted in 29.5 %, 28.07% and 29.8 % higher yield as compared to the un mulched treatment T1, T3 & T5. Therefore, it is revealed that even by mulching with LLDPE of bi color of 25 micron through drip irrigation resulted in 29.12 % higher yield of cauliflower as compared to un mulched. The higher yield in mulch treatment might be due to conservation of moisture, weed smothering, warmth to root zone for conducive micro climate.

The effect of planting system with mulching on available nutrient and uptake in cauliflower is depicted in Table 5. The polythene mulched flat bed (T_2) recorded 4.73 % increase in N uptake over without mulched flat bed (T_1). The polythene mulched broad bed (T_4) registered 6.25 % increase in N uptake over without mulched broad bed (T_3). Similarly, the ridge and furrow polythene mulched (T_6) resulted in 8.2 % increase in N uptake over without unmulched ridge and furrow (T_5). The higher N-uptake in the planting systems with polythene mulch compared to non-mulch was attributed to favourable influence of nitrogen on root proliferation and anchorage which in turn absorbed higher amount of nutrients from rhizosphere and supplied to the crop resulting in higher dry matter production (Umesh 2008). The highest available N content in post harvest soil of cauliflower was 275 kg ha^{-1} in the T_6 treatments and was significantly ($P \leq 0.05$) better than T_1, T_2, T_3 and T_5 treatments.

The different systems of planting viz. flat bed with polythene mulch (T_2), broad bed with polythene mulch (T_4) and ridge and furrow with polythene mulch (T_6) registered 11.1, 12.3 and 15.4 % increase in P uptake in cauliflower over their corresponding treatments without polythene mulch (T_1, T_3 and T_5), respectively. The higher P-uptake in mulch treated planting system compared to non-mulch was attributed to the more root proliferation and root volume which resulted in higher uptake (Ashrafuzzaman *et al*., 2011). The highest available P content was 36 kg ha^{-1} in the T_6 treatment and found no significant ($P > 0.05$) difference among the treatments.

The highest K uptake was 117 kg ha^{-1} in polythene mulched broad bed (T_4) and ridge and furrow (T_6) and was statistically at par with the without mulched broad bed (T_3) and ridge and furrow (T_5) planting. The available K content in post harvest soils of cauliflower varied from 275 to 300 kg ha^{-1}. Pinjari (2007) reported that nitrogen, phosphorus and potassium uptake in the leaves, stem, cob sheath, cob axis, kernels were significantly ($P \leq 0.05$) higher under polythene mulch than no mulch.

Irrigation water use efficiency worked out as the ratio between total cauliflower production and the seasonal irrigation water used throughout the cropping season. The irrigation water use efficiency varied significantly among treatments of planting methods and mulched one. The mulched treatment irrespective of methods of planting recorded higher irrigation water use efficiency. The highest average irrigation water use efficiency of 11.7 kg m^{-3} was recorded in ridge and furrow with mulch followed by broad bed with mulch (11.03 kg m^{-3}) and flat bed with mulch (10.37 kg m^{-3}. These results are in conformity with the findings of Lin *et al.*, 2015 that mulching is one of the good management practices to improve water use efficiency. Lie *et al*., 2001 also reported that both the grain yield and water use efficiency are increased by mulching. Similar to irrigation water use efficiency, the mulched treatment irrespective of methods of planting recorded higher gross economic water productivity. The highest gross economic water productivity was observed in ridge and furrow with mulch of 118.78 kg m^{-3}followed by broad bed with mulch (110.44 Rs $m^{-3)}$ and in flat bed with mulch (103.75 Rs m^{-3}).

The economic feasibility as influenced by planting methods in conjunction with or without LLDPE mulch in cauliflower is presented in Table 4. The maximum net returns of Rs 1,55,672/ha with BC ratio of 1.63 was recorded in treatment T_6 (ridge and furrow with mulch) and minimum net return of Rs 38,572/ha with a B:C ratio of 1.17 was recorded in flat bed without mulch (T_1). It was observed that methods of planting with LDPE bicolor mulch gave a maximum net return & benefit cost ratio than their corresponding treatments without mulching. The result was found in conformity with the findings of Paul *et al*., 2013 that the mulched treatment gave better net return per ha than their corresponding treatments without mulching. The results are also in conformity with the findings of Singh (2007) and Mishra *et al.*, 2008. The net profit was found maximum in case of mulched treatment followed by corresponding treatment without mulch. It was evident from the observation that a maximum percentage of net return of 185.12 % was recorded in flat bed with mulch compared to non mulched followed by broad bed with mulch and non mulched (140.19%) and least in ridge and furrow with mulch and non mulch (113.62 %).

CONCLUSIONS

The moisture content in LLDPE bicolour 25 micron silver black mulch planted in cauliflower registered higher over without mulched system irrespective of methods of planting. The ridge and furrow with mulch was found beneficial for earliness, higher curd yield, irrigation water use efficiency and gross economic water productivity of cauliflower.

Similarly, the ridge and furrow with polythene mulched resulted in increased N, P and K uptake over non mulched ridge and furrow. The result revealed that maximum net returns can be obtained in ridge and furrow with mulch. However, flat bed with mulch may be practiced in cauliflower as flat bed with mulch yielded at par with ridge & furrow without mulch. Thus, outcome of experimentation reveals that the use of poly ethylene mulch in conjunction with drip irrigation is a tool for enhancing the land and water use efficiency, gross economic water productivity and economic returns from cauliflower in acidic soil of eastern hill plateau hill region of India.

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Table 1: Growth Attributes as Influenced by Planting Methods in Conjunction with or without LLDPE Mulch in Cauliflower

Treatment	Plant Height (Cm) (30 DAT)					Plant Height (Cm) (Final Stage)					No. of Leaves at Final Stage				
	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean
T1 (FB)	19.75	22.00	26.72	21.14	22.47	39.72	42.72	43.6	43.75	42.45	16.53	16.80	18.15	18.04	17.38
T2 (FB + M)	29.75	31.03	31.35	30.93	30.78	41.15	45.22	49.75	46.25	45.59	17.18	17.70	19.15	18.38	18.10
T3 (BB)	26.05	24.05	26.65	23.10	24.96	40.75	43.52	42.33	45.91	43.13	17.68	17.43	18.63	18.20	17.99
T4 (BB+M)	29.38	30.20	32.57	30.85	30.75	42.1	44.87	46.55	45.31	44.71	18.05	18.20	18.55	18.95	18.44
T5 (R&F)	26.8	25.90	27.87	25.33	26.48	43.18	44.82	43.28	45.24	44.13	18.78	18.63	19.82	18.53	18.94
T6 (R&F+M)	32.63	30.15	34.87	29.85	31.88	44.88	44.35	47.82	45.85	45.73	19.18	19.20	19.21	19.48	19.27
Cd (0.05)	3.28	2.95	2.3	3.02		NS	NS	NS	NS		NS	NS	NS	NS	

FB (Flat bed); FB+M (Flat bed with plastic mulch); BB (Broad bed); BB+M (Broad bed with plastic mulch); R&F (Ridge and furrow); R&F+M (Ridge and furrow with plastic mulch)

Table 2: Curd Initiation and Weed Bio Mass As Influenced by Planting Methods in Conjunction with or without LDPE Mulch in Cauliflower

Treatment	Curd Initiation (No.)					Weed Bio Mass (Kg M-2)				
	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean
T1 (FB)	2.25	3.00	3.5	6.25	3.75	0.29	1.2	1.02	0.82	0.83
T2 (FB + M)	16.00	14.75	17.0	16.5	16.06	0.14	0.54	0.51	0.52	0.43
T3 (BB)	4.75	6.00	6.00	7.25	6.0	0.24	1.24	1.11	0.93	0.88
T4 (BB+M)	26.5	23.5	24.5	25.0	24.88	0.08	0.60	0.62	0.56	0.47
T5 (R&F)	13.5	16.00	14.25	14.75	14.63	0.31	1.28	1.05	1.05	0.92
T6 (R&F+M)	36.5	35.25	33.50	27.75	33.0	0.05	0.54	0.56	0.54	0.42
Cd (0.05)	10.52	9.24	9.08	7.13		0.01	0.49	0.33	0.18	

Table.3: Yield Attributes, Irrigation Water Use Efficiency & Economic Water Productivity as Influenced by Planting Methods in Conjunction with or without LLDPE Mulch in Cauliflower

Treatment	Yield Plant-1 (Kg)					Yield Ha-1 (Ton)					Irrigation Water Use Efficiency (IWUE) Kg M-3					Gross Economic Water Productivity (EWP) Rs M-3				
	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean
T1 (FB)	0.97	0.80	0.90	0.78	0.86	40.75	14.46	23.03	29.38	26.91	10.86	3.85	9.59	07.83	08.03	110.14	38.55	95.94	78.24	80.71
T2 (FB + M)	1.24	0.96	1.00	0.89	1.02	47.34	25.47	29.09	37.48	34.85	12.60	6.79	12.11	09.99	10.37	126.23	67.91	121.19	99.90	103.75
T3 (BB)	1.01	0.78	0.80	0.86	0.86	41.85	21.65	22.47	30.45	29.11	11.16	5.77	09.36	08.11	08.60	111.60	57.73	93.62	81.67	86.16
T4 (BB+M)	1.23	0.97	0.87	0.95	1.00	48.61	31.82	29.25	39.45	37.28	12.96	8.45	12.18	10.51	11.03	129.63	85.18	121.89	105.05	110.44
T5 (R&F)	1.19	0.86	0.82	0.93	0.95	43.74	26.07	22.46	32.3	31.14	11.66	6.95	09.33	08.60	9.14	116.62	69.52	93.58	86.03	91.44
T6 (R&F+M)	1.27	0.96	0.92	1.06	1.05	54.61	35.79	29.43	41.83	40.42	14.56	9.54	12.26	11.17	11.88	145.62	95.44	122.61	111.45	118.78
Cd (0.05)	0.12	0.21	0.08	0.11		8.30	7.94	4.36	4.81		2.21	2.12	1.82	1.27		21.79	21.24	18.16	13.05	

Table 4: Economic Analysis of Various Treatment As Influenced By Planting Methods In Conjunction with or Without LLDPE Mulch in Cauliflower

Sl. No.	Cost Economics (Rs Ha-1)	Treatment					
		T1(FB)	T2(FB + M)	T3(BB)	T4(BB+M)	T5(R&F)	T6(R&F+M)
1	Fixed cost (Rs)	31,808	31,808	31,808	31,808	31,808	31,808
2	Cost of cultivation (Rs)	1,98,720	2,06,720	2,06,720	2,14,720	2,06,720	2,16,720
3	Total cost of cultivation (Rs)	2,30,528	2,38,528	2,38,528	2,46,528	2,38,528	2,48,528
4	Yield of produce (Ton)	26.91	34.85	29.11	37.28	31.14	40.42
5	Rate (Rs ton-1)	10,000	10,000	10,000	10,000	10,000	10,000
6	Gross return (Rs)	2,69,100	3,48,500	2,91,100	3,72,800	3,11,400	4,04,200
7	Net return (Rs)	38,572	1,09,972	52,572	1,26,272	72,872	1,55,672
8	Benefit : Cost ratio	1.17	1.46	1.22	1.51	1.31	1.63

Table 5: Effect of Planting System with Mulching on Available Nutrient and Uptake in Cauliflower

Treatment	Nitrogen (Kg Ha-1)		Phosphorus (Kg Ha-1)		Potassium (Kg Ha-1)	
	Crop Uptake	Available N	Crop Uptake	Available P	Crop Uptake	Available K
T1 (FB)	148c	241c	14.21c	30a	98c	277b
T2 (FB + M)	155b	254b	15.79abc	32a	107b	278b
T3 (BB)	160b	250b	14.82bc	31a	116a	279b
T4 (BB+M)	170a	271a	16.65ab	33a	117a	295a
T5 (R&F)	159b	258b	14.85bc	32a	112ab	275b
T6 (R&F+M)	172a	275a	17.13a	36a	117a	300a

Within a column, values indicated by the same letters are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT).

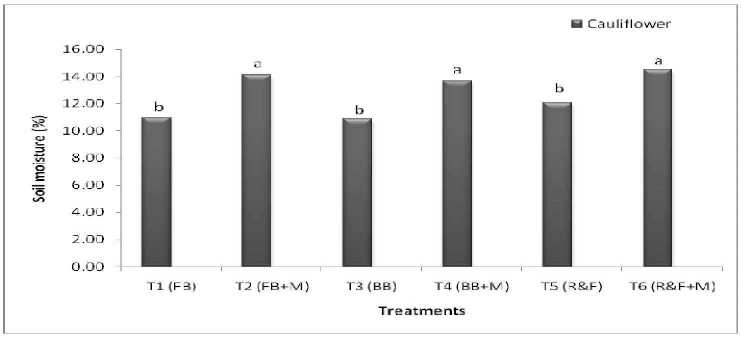

Figure.1: Soil Moisture Content (%) At 0-15 Cm Depth Under Different Planting Systems with Mulching in Cauliflower